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DECLARATION AS TO ACCURACY OF TRANSLATION OF JAPANESE PATENT APPLICATION 2000-291489

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hereby declare that:

1. I am well acquainted with both the English language and the Japanese language and am a translator of documents of either of the languages into the other of the languages;

2. I have translated into the English language the original Japanese language Specification of Japanese Patent Application 2000-291489, filed in Japan, on September 26, 2000;

3. A copy of my English language translation of the original Japanese language Specification of the Japanese Patent Application 2000-291489 is attached to this document; and

4. I hereby certify that, to the best of my knowledge and belief, the English language translation is a true and accurate translation of the original Japanese language Specification of the Japanese Patent Application 2000-291489.

I hereby declare that all statements made in this document of my own knowledge are true. I hereby declare that all statements made in this document on information and belief are believed to be true. Furthermore, I hereby declare that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued as a result of the application.

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【TITLE OF THE INVENTION】 APPARATUS FOR GENERATING THREE-DIMENSIONAL SHAPE DATA

【SCOPE OF CLAIMS】

【CLAIM 1】

A three-dimensional shape data generating apparatus comprising:

a three-dimensional measurement device for generating three-dimensional data by measuring a three-dimensional shape of an object;

a position and posture changing device for changing a position or a posture of the object;

a relative position sensing portion for detecting a relative position and a relative posture between the three-dimensional measurement device and the object; and

an integrating portion for integrating plural sets of three-dimensional data based on a detection result of the relative position sensing portion,

wherein a part of the relative position sensing portion is provided in each of the three-dimensional measurement device and the position and posture changing device.

【CLAIM 2】

The apparatus according to claim 1, wherein the relative position sensing portion includes a measurement position sensor for detecting a position and a posture of the three-dimensional measurement device, an object position sensor for detecting a position and a posture of the object, and an operation portion for calculating a relative position and a relative posture between the three-dimensional measurement device and the object based on detection results of the measurement position sensor and the object position sensor.

【CLAIM 3】

The apparatus according to claim 2, wherein the measurement position sensor moves in line with a change of the position and the posture of the three-dimensional measurement device.

【CLAIM 4】

The apparatus according to claim 3, wherein the object position sensor is provided in an immovable part of the position and posture changing device and the operation

portion calculates a relative position or a relative posture between the three-dimensional measurement device and the object based on an amount of change of the position and posture changing device.

【CLAIM 5】

The apparatus according to claim 3, wherein the object position sensor moves in line with a change of a position and a posture of the position and posture changing device, and the operation portion calculates a relative position or a relative posture between the three-dimensional measurement device and the object based on a relative position and a relative posture between the measurement position sensor and the object position sensor.

【DETAILED EXPLANATION OF THE PRESENT INVENTION】

【0001】

【TECHNICAL FIELD OF THE PRESENT INVENTION】

The present invention relates to an apparatus for generating three-dimensional shape data in which a set of three-dimensional data are generated by integrating plural sets of three-dimensional data obtained by measuring an object from different positions.

【0002】

【PRIOR ART】

Fig. 13 shows an example of conventional system for obtaining plural sets of three-dimensional data by measuring an object from different positions.

【0003】

In order to generate three-dimensional data of a shape of a whole periphery (an outline) of an object, it is necessary to conduct plural times of three-dimensional measurements of the object from different positions and to integrate the plural sets of three-dimensional data.

【0004】

For example, three-dimensional data of an upper body of a person are obtained by integrating plural sets of three-dimensional data obtained by measuring a front side, a left side, a right side, a back side and so on of the person.

【0005】

Even when three-dimensional data that do not require data for a whole periphery such as a human face are desired, three-dimensional data that are generated by measuring an

object from one position may have a low-accuracy portion or an incomplete portion due to occlusion. Accordingly, a need may arise to integrate plural sets of three-dimensional data obtained by measuring an object from different positions to compensate a low-accuracy portion or an incomplete portion.

【0006】

For such occasions, a method shown in Fig. 13 is proposed. The three-dimensional measurement device 91 shown in Fig. 13 generates three-dimensional data of the object Q by the light section method or the like. The turn table 92 rotates about the rotational axis L' to change a relative position or a relative posture between the object Q set thereon and the three-dimensional measurement device 91. A relative position and a relative posture between the three-dimensional measurement device 91 and the rotational axis L' are fixed. As the processor 93, there may be used a computer device including a personal computer or workstation.

【0007】

Plural sets of three-dimensional data of the object Q are obtained by rotating the turn table 92 and changing the relative position or the relative posture between the object Q and the three-dimensional measurement device 91. The processor 93 integrates the plural sets of three-dimensional data based on a rotational angle of the turn table 92 during the generation of the plural sets of three-dimensional data, the relative position and the relative posture between the three-dimensional measurement device 91 and the rotational axis L' and so on, to thereby generate a set of three-dimensional data.

【0008】

【MEANS TO SOLVE THE PROBLEM】

According to the conventional method described above, all side faces of the object Q can be included in a measuring range of the three-dimensional measurement device 91, leading to solution of a problem of occlusion that occurs in side faces.

【0009】

However, parts such as a human head that cannot be included in the measuring range of the three-dimensional measurement device 91 even when rotating the turn table 92

may sometimes be left unmeasured. Further, a case may arise in which a part having a complicated shape such as chin, nose or ears may sometimes be left unmeasured partly.

【0010】

Accordingly, three-dimensional data that are generated by integrating plural sets of three-dimensional data using the method mentioned above may sometimes have a low-accuracy portion or a portion whose shape is unspecified.

Moreover, a position and an axial direction of the rotational axis L with respect to the three-dimensional measurement device 91 needs to be calculated by using, for example, a specific chart in order to decide the relative position and the relative posture between the three-dimensional measurement device 91 and the turn table 92 in advance of the three-dimensional measurement. Such system may impose an extra workload on a user and may cause increase in the production cost.

【0011】

An object of the present invention is to solve problems as described above. Another object of the present invention is to reduce immeasurable parts compared to conventional methods. Yet another object of the present invention is to provide a system for generating highly precise three-dimensional data of an object having a complicated shape. Yet further object of the present invention is to reduce workload on a user.

【0012】

〔PROBLEM TO BE SOLVED BY THE PRESENT INVENTION〕

A three-dimensional shape data generating apparatus includes a three-dimensional measurement device for generating three-dimensional data by measuring a three-dimensional shape of an object, a position and posture changing device for changing a position or a posture of the object, a relative position sensing portion for detecting a relative position and a relative posture between the three-dimensional measurement device and the object, and an integrating portion for integrating plural sets of three-dimensional data based on a detection result of the relative position sensing portion, wherein a part of the relative position sensing portion is provided in each of the three-dimensional measurement device and the position

and posture changing device.

【0013】

Preferably, the relative position sensing portion includes a measurement position sensor for detecting a position and a posture of the three-dimensional measurement device and an object position sensor for detecting the position and the posture of the object. A relative position and a relative posture between the three-dimensional measurement device and the object are detected based on detection results of each of the measurement position sensor and the object position sensor.

【0014】

Further, the measurement position sensor moves in line with a change of the position and the posture of the three-dimensional measurement device.
Furthermore, the object position sensor is provided in an immovable part of the position and posture changing device and the operation portion calculates a relative position or a relative posture between the three-dimensional measurement device and the object based on an amount of change of the position and posture changing device.
Alternatively, the object position sensor moves in line with a change of a position and a posture of the position and posture changing device, and the operation portion calculates a relative position or a relative posture between the three-dimensional measurement device and the object based on a relative position and a relative posture between the measurement position sensor and the object position sensor.

【0015】

【EMBODIMENT OF THE PRESENT INVENTION】

[First Embodiment]

Fig. 1 shows a three-dimensional shape data generating apparatus 1 according to a first embodiment of the present invention, Fig. 2 illustrates a principle of a three-dimensional position sensor 14 and so on, Fig. 3 shows an example of a relative position and a relative posture between a transmitter 14a and a receiver 14b. Fig. 4 is a block diagram showing a functional configuration of the three-dimensional shape data generating apparatus 1 according to the first embodiment, and Fig. 5 shows five sets of three-dimensional coordinate systems present in a

space S.

[0016]

As shown in Fig. 1, the three-dimensional shape data generating apparatus 1 includes a three-dimensional measurement device 11, a position and posture changing device 12, a computer device 13, a three-dimensional position sensor 14 and the like.

[0017]

The three-dimensional measurement device 11 comprises a three-dimensional camera 11a, a support medium 11b and the like.

The three-dimensional camera 11a serves to perform three-dimensional measurement of an object Q and to generate three-dimensional data DT. For example, a three-dimensional camera that can measure depths and luminances of points in a single dimensional or two-dimensional image area may be used as the three-dimensional camera 11a. Also, the three-dimensional data DT may be generated by photographing the object Q using plural optical cameras set at different positions to obtain two-dimensional images, and then detecting corresponding points of the obtained two-dimensional images by the stereo imaging method. Further, it is possible to use the three-dimensional camera 11a only for three-dimensional measurement and to use the computer device 13 for generating the three-dimensional data DT based on a result of the three-dimensional measurement.

[0018]

The support medium 11b supports the three-dimensional camera 11a at an arbitrary position or an arbitrary posture. A tripod mount may be used as the support medium 11b, for example. A user may arrange the three-dimensional camera 11a at an arbitrary position or posture by, for example, adjusting a position or a height of the tripod mount. The support medium may be adapted to automatically adjust its position or posture by means of power of a motor 11c or the like in accordance with a command transmitted by the computer device 13.

[0019]

The position and posture changing device 12 comprises a turn table 12a, a support board 12b and so on.

The support board 12b is provided as being fixed with

respect to space S and serves to rotationally drive the turn table 12a provided thereon. The object Q is placed on the turn table 12a. The turn table 12a changes a position or a posture of the object Q by rotating about the rotational axis L in the vertical direction by means of power of a motor 12c in accordance with a command transmitted from the computer device 13.

【0020】

The computer device 13 comprises a CPU, a RAM, a ROM, a magnetic memory device, a keyboard, a mouse, a program and data memorized in the RAM and so on. The computer device 13 serves to generate a desired set of three-dimensional data DTT based on plural sets of three-dimensional data DT, to perform an operation for controlling the three-dimensional measurement device 11 or the position and posture changing device 12 and to carry out processing for other various operations.

【0021】

The computer device 13, the three-dimensional measurement device 11 and the position and posture changing device 12 are connected to one another via a cable or wireless communication.

The three-dimensional position sensor 14 comprises a transmitter 14a, receivers 14b, a control unit 14c and the like and serves to detect a relative position and a relative posture between the transmitter 14a and each of the receivers 14b in the space S.

【0022】

The transmitter 14a is mounted on the three-dimensional camera 11a, and a position or a posture thereof changes in accordance with a change of the position or the posture of the three-dimensional camera 11a. The receivers 14b are mounted on the support board 12b at different positions and are fixed with respect to the space S. It is possible to detect the positions and postures of the three-dimensional measurement device 11 and the object Q by detecting the positions and the postures of the transmitter 14a and the receivers 14b and then performing an operation by the position and posture operating portion 130 to be described later in this specification. The receivers 14b may sometimes be separately referred to as a receiver 14b1 and a receiver 14b2 as required.

[0023]

The control unit 14c comprises a drive circuit 14c1, a detection circuit 14c2 and an output portion 14c3 and so on. The drive circuit 14c1 serves to send alternating current to the transmitter 14a, and the detection circuit 14c2 serves to detect an output signal from the receivers 14b. The output portion 14c3 transmits the detection result and the like to the computer device 13. The computer device 13 calculates the relative position between the transmitter 14a and the receivers 14b as well as the relative posture therebetween based on the detection result and so on.

[0024]

A principle of the three-dimensional position sensor 14 will be described below. As shown in Fig. 2, the transmitter 14a comprises an orthogonal coil. A magnetic field occurs when alternating current is applied to the orthogonal coil. Each of the receivers 14b comprises an orthogonal coil, and inductive current is produced in the orthogonal coil when the receivers 14 are placed in the magnetic field of the transmitter 14a. The inductive current is measured at the detection circuit 14c2, and three-dimensional coordinate (rx, ry, rz) and Eulerian angle (α, β, γ) are calculated from the measurement result, characteristics of the altering current applied to the transmitter 14a and so on.

[0025]

As shown in Fig. 3, the three-dimensional coordinate (rx, ry, rz) represents positions of the receivers 14b with respect to the transmitter 14a, and each of the values of α, β and γ represents a rotational angle (roll), an elevation angle (pitch) and an azimuth angle (yaw).

[0026]

As the three-dimensional position sensor 14, there may be used "Inside Track" of Polhemus.

Operating condition of commercially available three-dimensional position sensor is such that a distance between a transmitter and a receiver must be about 3 meters or less. Accordingly, two receivers 14b are mounted on the support board 12b at different positions in the present embodiment so that a position or a posture of either one of the receivers in above-mentioned operating condition is detected even when a position or a posture of the three-

dimensional camera 11a is changed.

【0027】

Above-described structure enables the three-dimensional shape data generating apparatus 1 to realize the functions shown in Fig. 4.

As shown in Fig. 4, the computer device 13 realizes the functions of the position and posture operating portion 130, the three-dimensional data integrating portion 131, the camera controlling portion 132 and the table controlling portion 133 by operating the program memorized in the RAM or the like in the CPU.

【0028】

The position and posture operating portion 130 serves to calculate a relative position and a relative posture between the three-dimensional camera 11a and the object Q and to perform coordinate conversion of the three-dimensional data DT according to the calculation results. Details of the calculation and the coordinate conversion will be described below.

【0029】

The three-dimensional data integrating portion 131 integrates plural sets of three-dimensional data DT that have been subjected to the coordinate conversion by the position and posture operating portion 130 and generates desired three-dimensional data DTT.

The camera controlling portion 132 controls the three-dimensional measurement device 11 by transmitting a control command to the motor 11c for control of the position or the posture of the three-dimensional camera 11a, by transmitting data to the three-dimensional camera 11a by calculating measurement conditions regarding an exposure value and so on or by performing processing such as transmitting a command for executing a three-dimensional measurement to the three-dimensional camera 11a.

【0030】

The table controlling portion 133 controls the position and posture changing device 12 by transmitting to the motor 12c a command, data or the like for controlling rotation of the turn table 12a.

【0031】

Plural frames 13m are memorized in the memory area 134. The frames 13m are a collection of data for each of

three-dimensional data DT, a rotational angle θ of the turn table 12a when the three-dimensional data DT is generated, a three-dimensional coordinate (rxn, ryn, rzn, wherein n = 1, 2) of each of the receivers 14b1 and 14b2 and Eulerian angle (αn, βn, γn, wherein n = 1, 2). Accordingly, the number of the frames 13m is the same as the number of measurements of the object Q.

【0032】

Processing in the position and posture operating portion 130 will be described below. In order to integrate plural sets of three-dimensional data DT, it is necessary to impose uniformity to coordinate systems of all the three-dimensional data to be used for the integration. Accordingly, the three-dimensional data DT are converted into an identical three-dimensional coordinate system by using a conversion matrix M indicated by the following expression (1).

【0033】

M = Tct • Ttr • Rtr • Trb • Rbo .... (1)

wherein,

Rtr

$$= \begin{pmatrix} \cos(-\alpha) & -\sin(-\alpha) & 0 \\ \sin(-\alpha) & \cos(-\alpha) & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} \cos(-\beta) & 0 & -\sin(-\beta) \\ 0 & 1 & 0 \\ \sin g(-\beta) & 0 & \cos(-\beta) \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos(-\gamma) & -\sin(-\gamma) \\ 0 & \sin(-\gamma) & \cos(-\gamma) \end{pmatrix}$$

$$\mathrm{Rbo} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos(-\theta) & -\sin(-\theta) \\ 0 & \sin(-\theta) & \cos(-\theta) \end{pmatrix}$$

【0034】

As shown in Fig. 5, exist in the space S are five three-dimensional coordinate systems: a transmitter coordinate system Otr that is a three-dimensional coordinate system in the magnetic field occurring from the transmitter 14a; a camera coordinate system Oc having a visual line of the three-dimensional camera 11a as one of its axis; a receiver coordinate system Or that is a three-dimensional coordinate composed of the orthogonal coil of the receivers 14b; a turn table coordinate system Otb having the rotational axis L of the turn table 12a as one of its axis; and an object coordinate system Oo having an axis passing through the object Q in vertical direction as

one of its axis.

【0035】

In the expression (1), Tct serves to convert the camera coordinate system Oc into the transmitter coordinate system Otr. Tct is a predefined value as a positional relationship between visual points of the transmitter 14a and the three-dimensional camera 11a is known.

【0036】

Ttr serves to parallely move the three-dimensional coordinates (rx, ry, rz) of the receivers 14b. Rtr serves to execute rotational movement about X axis by $-\alpha$, a rotational movement about Y axis by $-\beta$ and a rotational movement about Z axis by $-\gamma$. The transmitter coordinate system Otr is converted into the receiver coordinate system Or by estimating Ttr and Rtr in this order. Ttr and Rtr are calculated in the position and posture operating portion 130 in accordance with the detection result transmitted from the control unit 14c.

【0037】

Trb serves to convert the receiver coordinate system Or into the turn table coordinate system Otb. The positional relationship and the posture relationship between the receivers 14b and the turn table 12a is known and, therefore, Trb is a predefined value. Trb is defined with respect to each of the receivers 14b1 and 14b2.

【0038】

Rbo serves to execute rotational movement about the rotational axis L by θ to convert the turn table coordinate system Otb into the object coordinate system Oo. Rbo is calculated in the position and posture operating portion 130 in accordance with the output value from the encoder 12e.

Thus, conversion matrix M that is used for converting the camera coordinate system Oc into the object coordinate system Oo is determined by estimating the five conversion matrixes as the expression (1). In other words, the position and the posture of the three-dimensional camera 11a in the object coordinate system Oo is calculated by using the conversion matrix M, thereby calculating the relative position and the relative posture between the object Q and the three-dimensional camera 11a.

【0039】

By operating the conversion matrix M and each of the three-dimensional data DT, the three-dimensional coordinate systems of all the three-dimensional data DT are unified.

Hereafter, with reference to flowcharts, there will be described a processing of generating a set of desired three-dimensional data DTT by generating plural sets of three-dimensional data DT and integrating them.

【0040】

Fig. 6 is a flowchart illustrating a flow of processing of the three-dimensional shape data generating apparatus 1 according to the first embodiment; Fig. 7 is a flowchart illustrating processing of integrating three-dimensional data DT.

【0041】

Referring to Fig. 6, a rotational angle θ of the turn table 12a is reset to 0 (#11). Position and posture of the three-dimensional camera 11a are adjusted (#12), and then the turn table 12a is rotated to adjust a relative position and a relative posture between the object Q and the three-dimensional camera 11a (#13).

【0042】

After defining the position and the postures, the three-dimensional shape data generating apparatus 1 waits for a command for starting photographing from a user (#14). If the command is received by the three-dimensional shape data generating apparatus 1, the rotational angle θ of the turn table 12a is memorized in the frame 13m (#15), and positions and postures of the receivers 14b1 and 14b2 are detected, followed by memorizing the three-dimensional coordinates (rxn, rxy, rxz) and Eulerian angle (αn, βn, γn) in the frame 13m (#16).

【0043】

A command for starting a measurement is transmitted from the camera controlling portion 132 to the three-dimensional camera 11a, and the three-dimensional camera 11a generates the three-dimensional data DT by measuring the object Q. The three-dimensional data DT are memorized in the frame 13m (#17).

【0044】

The steps #12 to #17 are repeated with changing the relative position and the relative posture between the object Q and the three-dimensional camera 11a to obtain

three-dimensional data of the whole periphery or necessary parts of the object Q (#18).

【0045】

After obtaining the necessary three-dimensional data DT (Yes in #18), integration of the three-dimensional data DT is performed using data thus obtained and memorized in the frame 13m (#19).

【0046】

The integration of the three-dimensional data DT is performed in the processing order shown in Fig. 7. By reading out one of the frames 13m (#21), it is detected either one of the receivers 14b is closer to the transmitter 14a by calculating distances D from the receivers 14b to the transmitter 14a by using the following expression (2) (#22).

【0047】

$$Dn = (rxn^2 + ryn^2 + rzn^2)^{1/2} \quad .... \ (2)$$

Next, the conversion matrix M is calculated (#23). In above expression (2), there are used the three-dimensional coordinate and the Eulerian angle of either one of the receivers 14b that is detected to be closer to the transmitter 14a.

【0048】

By using the conversion matrix M, three-dimensional coordinates of the three-dimensional data are converted so that the converted three-dimensional coordinates correspond to the object coordinate system Oo (#24).

In the case where the three-dimensional coordinates of the three-dimensional data DT are converted with respect to all of the frames 13m (yes in #25), the converted three-dimensional data DT are integrated to obtain desired three-dimensional data DTT (#26). In the case where a part of the frame 13m is left unconverted (No in #25), process returns to the step #21 to repeat above processing for the part of the frame 13m.

【0049】

According to the three-dimensional shape data generating apparatus 1 of the first embodiment, it is possible to reduce immeasurable parts by measuring the object Q from arbitrary positions and generating three-dimensional data thereof and, further, it is possible to

obtain three-dimensional data that are high in precision even when the object has a complicated shape by integrating the generated three-dimensional data.

[Second Embodiment]

Fig. 8 shows the three-dimensional shape data generating apparatus 1B according to the second embodiment of the present invention. Fig. 9 is a block diagram showing a functional configuration of the three-dimensional shape data generating apparatus 1B according to the second embodiment. Fig. 10 shows four sets of three-dimensional coordinate systems existing in the space S2.

【0050】

In the Figs. 8 to 10, the functions or configuration that are the same as the first embodiment are assigned the same reference numerals as those of the first embodiment and descriptions overlapping to the first embodiment and the second embodiment are eliminated in the following.

【0051】

In the three-dimensional shape data generating apparatus 1 of the first embodiment, the receivers 14b are fixed on the support board 12b, thereby to be fixed with respect to the space S. As shown in Fig. 8, the receivers 14b are mounted on the turn table 12a in the three-dimensional shape data generating apparatus 1B of the second embodiment and, therefore, the receivers 14b move in accordance with rotation of the turn table 12a. In other words, the receivers 14b rotate about the rotational axis L with respect to the space S2.

【0052】

Further, three sets of the receivers 14b are mounted on the support board 12b at different positions. Other parts of the structure of the three-dimensional shape data generating apparatus 1B are the same as those of the three-dimensional shape data generating apparatus 1 of the first embodiment.

【0053】

Functions shown in Fig. 9 are realized on the three-dimensional shape data generating apparatus 1B by way of the above-described structure.

In Fig. 9, in the same manner as the position and posture operating portion 130, the position and posture operating portion 130B converts the three-dimensional data

DT into an identical three-dimensional coordinate system by using a conversion matrix M′ shown in the following expression (3).

【0054】

$$M' = Tct \bullet Ttr \bullet Rtr \bullet Tro \quad .... \quad (3)$$

wherein,

Rtr

$$= \begin{pmatrix} \cos\alpha & -\sin\alpha & 0 \\ \sin\alpha & \cos\alpha & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} \cos\beta & 0 & -\sin\beta \\ 0 & 1 & 0 \\ \sin\beta & 0 & \cos\beta \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\gamma & -\sin\gamma \\ 0 & \sin\gamma & \cos\gamma \end{pmatrix}$$

【0055】

As shown in Fig. 10, there are four sets of three-dimensional coordinate systems in the space S2: a transmitter coordinate system Otr, a camera coordinate system Oc, a receiver coordinate system OrB and an object coordinate system Oo. The receiver coordinate system Orb is a three-dimensional coordinate system formed by an orthogonal coil of the receivers 14b.

【0056】

In the expression (3), Tct converts the camera coordinate system Oc into the transmitter coordinate system Otr in the same manner as that of the expression (1).

Tro converts the receiver coordinate system OrB into the object coordinate system Oo. Tbo is a predefined value since a positional relationship between the receivers 14b and a table top of the turn table 12a, on which the object Q is to be placed, is known.

【0057】

Ttr and Rtr are estimated in this order to convert the transmitter coordinate system Otr into the receiver coordinate system OrB.

By estimating above four sets of conversion matrixes according to the expression (3), the conversion matrix M′ for converting the camera coordinate system Oc into the object coordinate system Oo is obtained.

【0058】

All the three-dimensional coordinate systems of the three-dimensional data DT to be used for integration are unified by operating the conversion matrix M′ and the three-dimensional data DT.

Other functional configurations are the same as the

first embodiment.

【0059】

Fig. 11 is a flowchart illustrating a flow of processing of the three-dimensional shape data generating apparatus 1B in the second embodiment.

As shown in Fig. 11, positions of the three-dimensional camera 11a and the turn table 12a are adjusted, and a relative position between the object Q and the three-dimensional camera 11a and a relative posture therebetween are adjusted (#31 and #32).

【0060】

After receiving a command for starting photographing from a user (#33), positions and postures of the receivers 14b are detected and three-dimensional coordinates and Eulerian angles thereof are memorized in the frame 13m (#34). The object Q is measured to generate three-dimensional data DT and the three-dimensional data DT are memorized in the frame 13m (#35).

【0061】

It is then judged if all of necessary three-dimensional data DT are obtained or not (#36). In the case where the three-dimensional data DT have been obtained, integration processing of the three-dimensional data DT is performed (#37). In the case where the three-dimensional data DT have not been obtained, process returns to the step #31 to generate the three-dimensional data DT that have not been obtained.

【0062】

According to the first and the second embodiments, a moving range of the transmitter 14a can be widened by mounting three receivers 14b, thereby enabling a user to easily perform three-dimensional measurement of a relatively large object.

【0063】

Fig. 12 shows a modification of the three-dimensional shape data generating apparatus 1B of the second embodiment.

The receivers 14b used in the second embodiment are mounted on the turn table 12a irrespective of the positions as long as they rotate in accordance with the rotation of the turn table 12a. For example, as shown in Fig. 12, either one of the receivers 14b may be attached to a bottom end of a connection bar 12d connected to an undersurface of

the turn table 12a in accordance with the rotation of the rotational axis L. Thus, since the receiver 14b rotates with the rotation of the turn table 12a, the desired three-dimensional data DTT are generated in the same manner as described above.

【0064】

In the first and second embodiments and modifications thereof, a configuration is possible in which the transmitter 14a and the receiver 14b are interchanged with each other. In such a case, three-dimensional coordinates and Eulerian angle of the three-dimensional camera 11a are measured with respect to the turn table 12a. Each element of the three-dimensional coordinates and Eulerian angle of the three-dimensional camera 11a is multiplied by "-1", which can convert the same into three-dimensional coordinates and Eulerian angle of the turn table 12a. Then, desired three-dimensional data DTT may be obtained by the method same as the embodiments described above or modifications thereof.

【0065】

It is possible to change the three-dimensional shape data generating apparatuses 1, 1B and 1C, structures of the apparatuses, contents of processing of the apparatuses, order of the processing and the like without departing from the spirit and scope of the present invention.

【0066】

【ADVANTAGEOUS EFFECT OF THE INVENTION】

According to each of the embodiments described above, it is possible to reduce immeasurable parts of an object even when the object has a complicated shape as compared with conventional methods and to generate three-dimensional data of such object with high precision. Additionally, preparation before three-dimensional measurement can be decreased, resulting in reducing user's workload.

【BRIEF DESCRIPTION OF THE DEAWINGS】

【Fig. 1】

Fig. 1 shows a three-dimensional shape data generating apparatus according to a first embodiment of the present invention.

【Fig. 2】

Fig. 2 illustrates a principle of the three-dimensional position sensor and so on.

【Fig. 3】

Fig. 3 shows an example of a relative position and a relative posture between a transmitter and a receiver.

【Fig. 4】

Fig. 4 is a block diagram showing a functional configuration of the three-dimensional shape data generating apparatus according to the first embodiment.

【Fig. 5】

Fig. 5 shows five sets of three-dimensional coordinate systems present in the space.

【Fig. 6】

Fig. 6 is a flowchart illustrating a flow of processing of the three-dimensional shape data generating apparatus according to the first embodiment.

【Fig. 7】

Fig. 7 is a flowchart illustrating processing of integrating three-dimensional data.

【Fig. 8】

Fig. 8 shows a three-dimensional shape data generating apparatus according to a second embodiment of the present invention.

【Fig. 9】

Fig. 9 is a block diagram showing a functional configuration of the three-dimensional shape data generating apparatus according to the second embodiment.

【Fig. 10】

Fig. 10 shows four sets of three-dimensional coordinate systems present in the space.

【Fig. 11】

Fig. 11 is a flowchart illustrating a flow of processing of the three-dimensional shape data generating apparatus according to the second embodiment.

【Fig. 12】

Fig. 12 shows a modification of the three-dimensional shape data generating apparatus according to the second embodiment.

【Fig. 13】

Fig. 13 shows a conventional system for obtaining plural sets of three-dimensional data of an object by measuring the object from different positions.

【EXPLANATION OF RFERENCES】

1, 1B three-dimensional shape data generating

	apparatus
11	three-dimensional measurement device
12	position and posture changing device
130, 130B	position and posture operating portion (operating means)
131	three-dimensional data integrating portion (integrating means)
14	three-dimensional position sensor (relative position detecting means)
14a	transmitter (measurement position detector)
14b	receiver (object position detector)
DT, DTT	three-dimensional data

【PAPER NAME】 Abstract

【ABSTRACT】

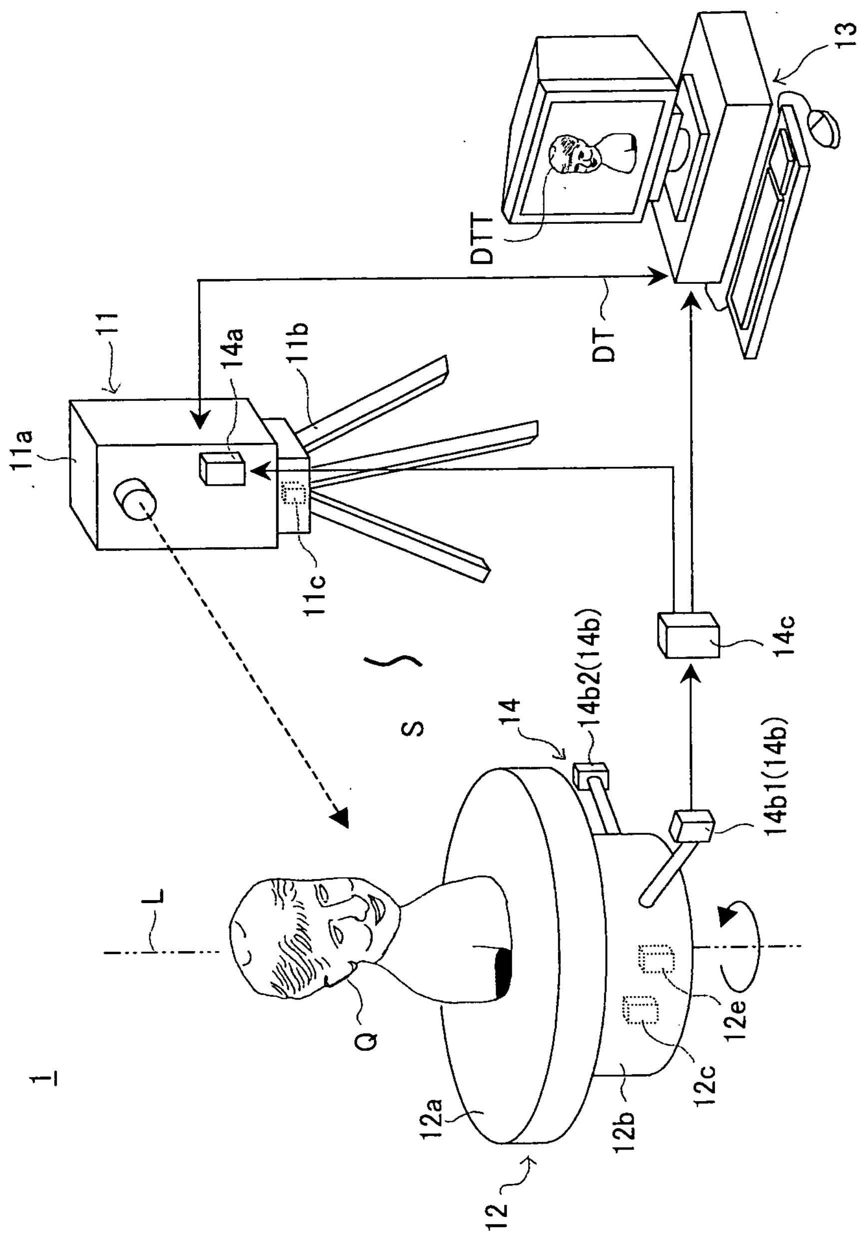
【PROBLEM】 The primary object of the invention is to reduce immeasurable parts of an object even when the object has a complicated shape as compared with conventional methods and to generate three-dimensional data of such object with high precision.

【MEANS TO SOLVE THE PROBLEM】 The apparatus is comprised by a three-dimensional measurement device 11 for measuring an object Q and generating three-dimensional data DT of the object Q, a control device 12 for changing a position or a posture of the object Q, a three-dimensional position sensor 14 for measuring a relative position or a relative posture between the three-dimensional measurement device 11 and the object Q, and a computer device 13 for integrating plural sets of three-dimensional data DT based on a measurement result of the three- dimensional position sensor 14.

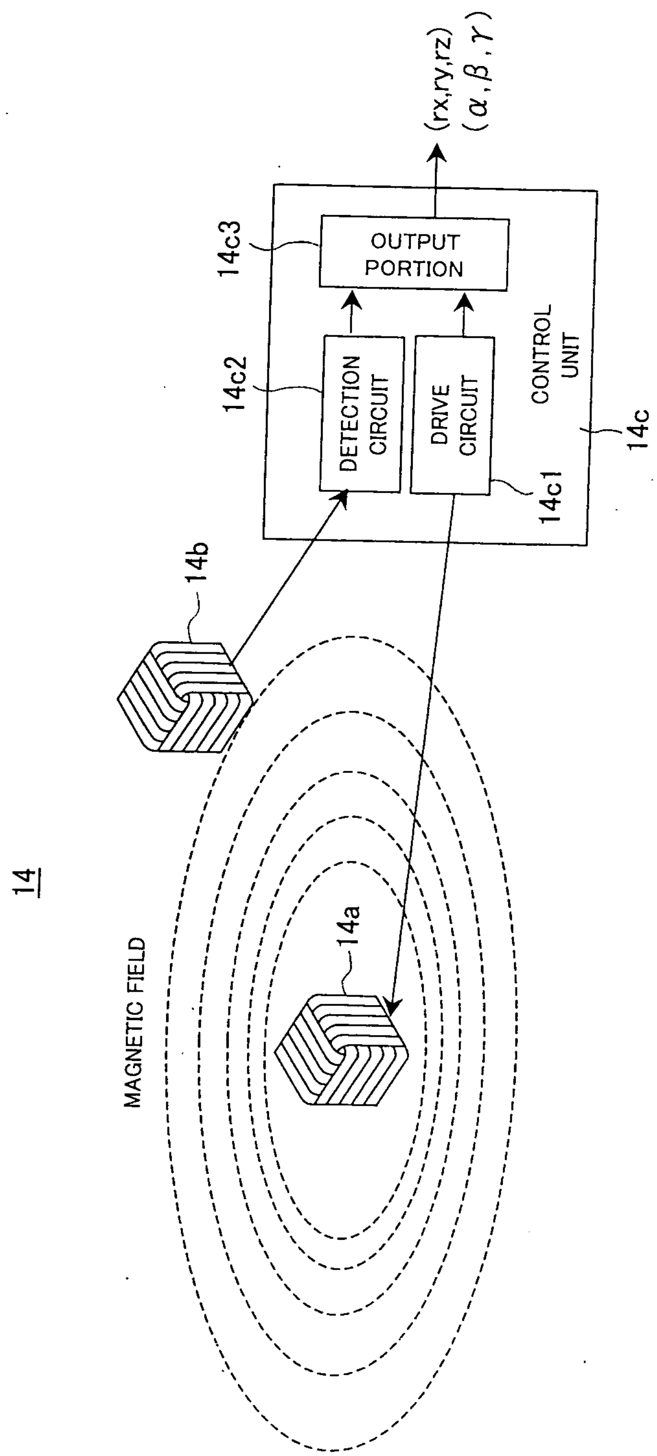
【SELECTED DRAWING】 Fig. 1

【PAPER NAME】 Drawings

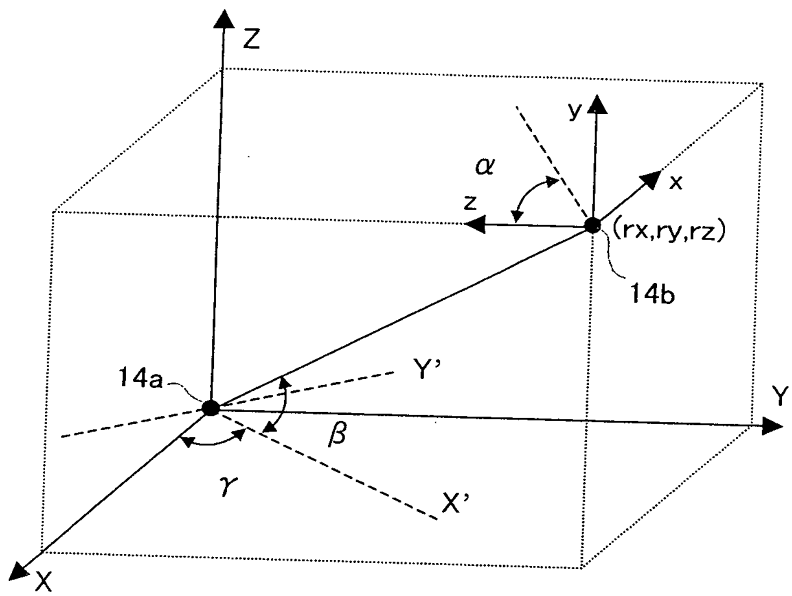
【FIG. 1】



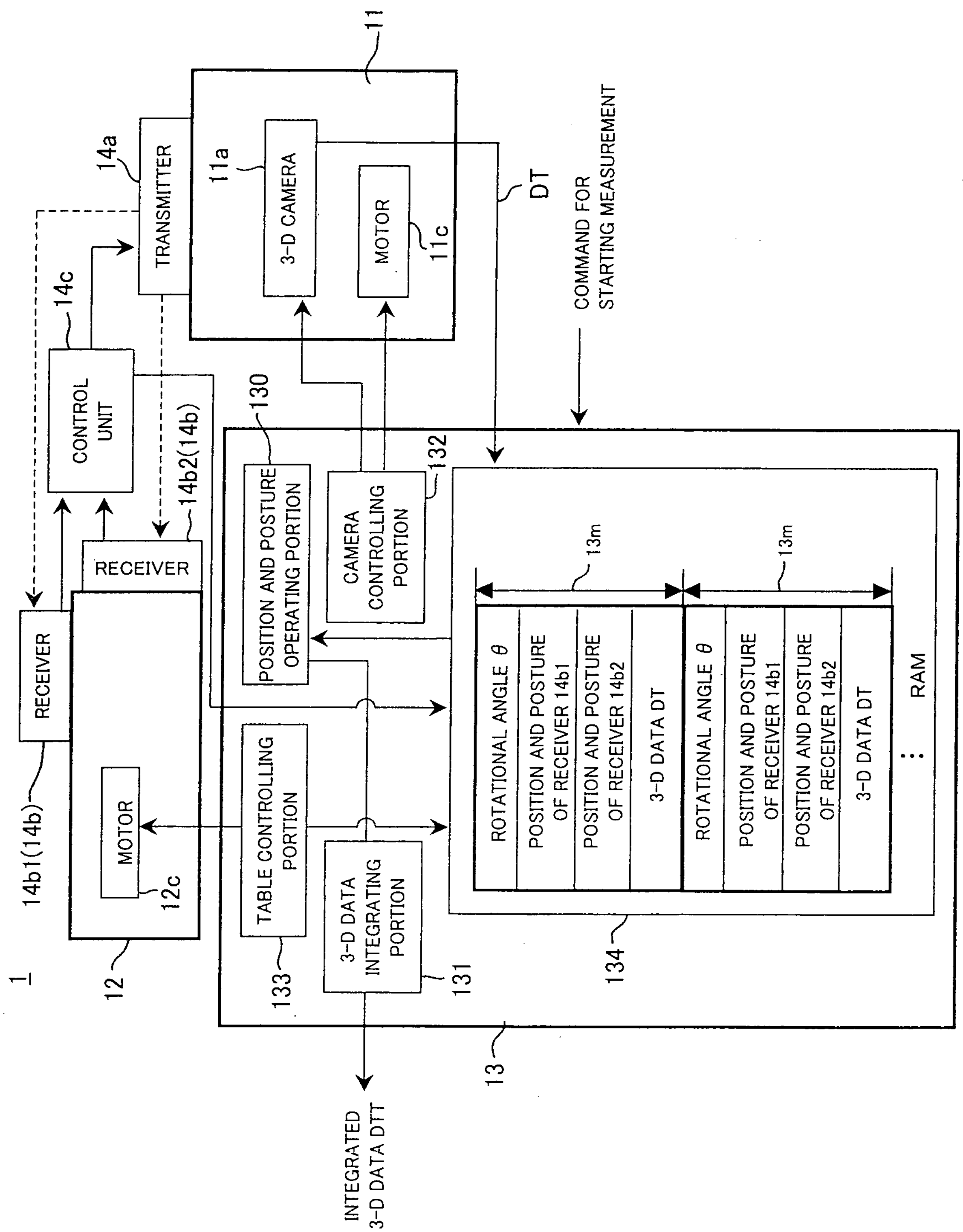
【FIG. 2】


(rx,ry,rz)
(α,β,γ)
OUTPUT PORTION
14c3
DETECTION CIRCUIT
14c2
DRIVE CIRCUIT
14c1
CONTROL UNIT
14c
14b
14
MAGNETIC FIELD
14a

【FIG. 3】

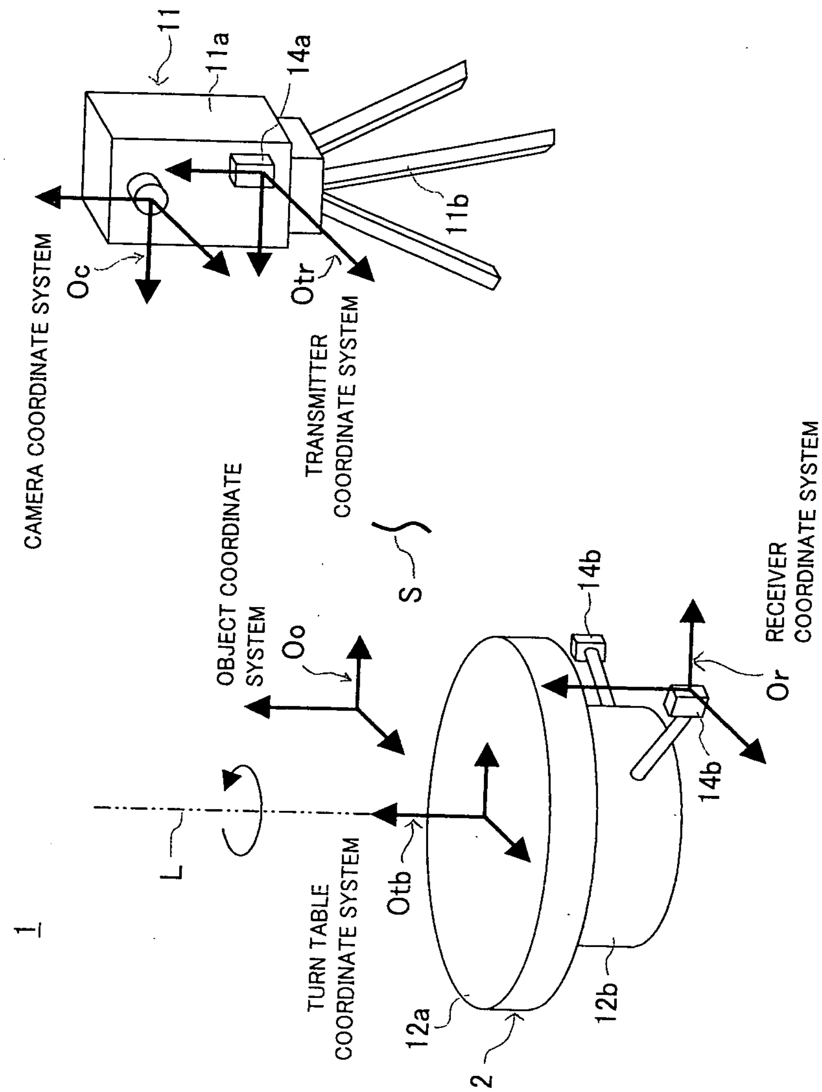


【FIG. 4】

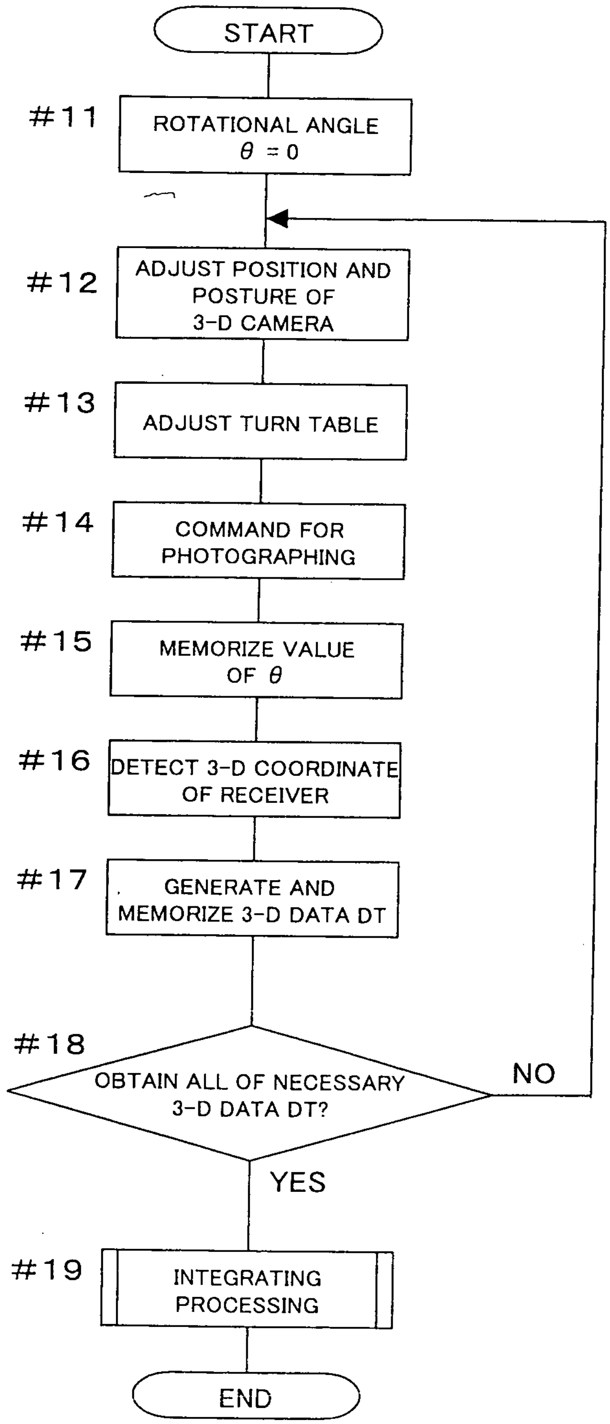


1
11
11a
3-D CAMERA
MOTOR
11c
14a
TRANSMITTER
14c
CONTROL UNIT
14b2(14b)
RECEIVER
RECEIVER
14b1(14b)
MOTOR
12c
12
DT
COMMAND FOR STARTING MEASUREMENT
130
POSITION AND POSTURE OPERATING PORTION
132
CAMERA CONTROLLING PORTION
13m
13m
ROTATIONAL ANGLE θ
POSITION AND POSTURE OF RECEIVER 14b1
POSITION AND POSTURE OF RECEIVER 14b2
3-D DATA DT
ROTATIONAL ANGLE θ
POSITION AND POSTURE OF RECEIVER 14b1
POSITION AND POSTURE OF RECEIVER 14b2
3-D DATA DT
RAM
TABLE CONTROLLING PORTION
133
3-D DATA INTEGRATING PORTION
131
134
13
INTEGRATED 3-D DATA DTT

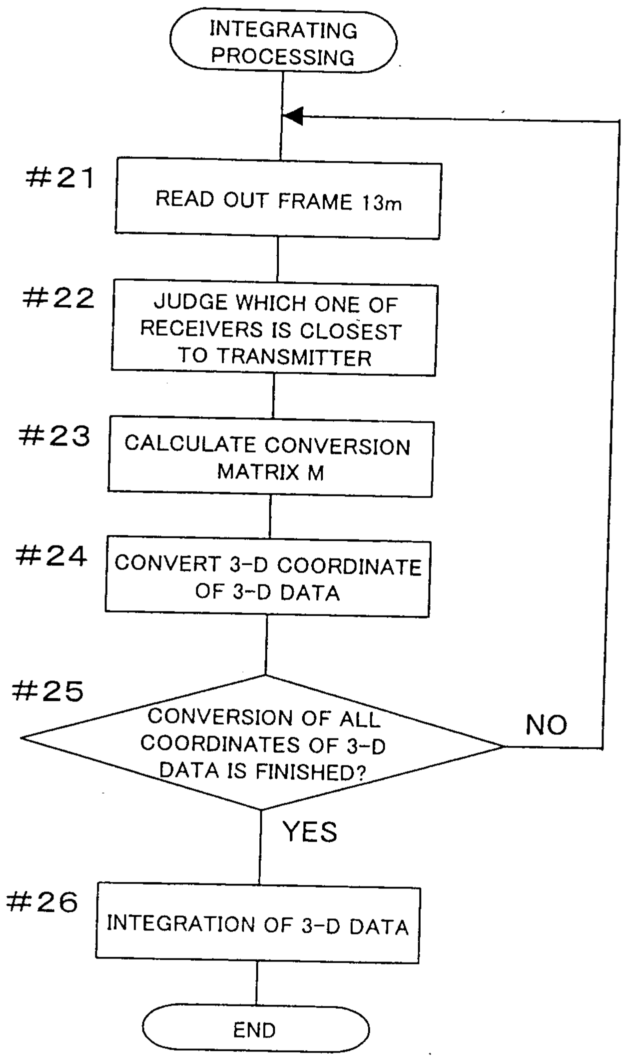
【FIG. 5】


11
11a
14a
11b
Oc
Otr
CAMERA COORDINATE SYSTEM
TRANSMITTER
COORDINATE SYSTEM
OBJECT COORDINATE
SYSTEM
Oo
S
14b
RECEIVER
COORDINATE SYSTEM
Or
14b
L
1
Otb
TURN TABLE
COORDINATE SYSTEM
12a
12
12b

【FIG. 6】

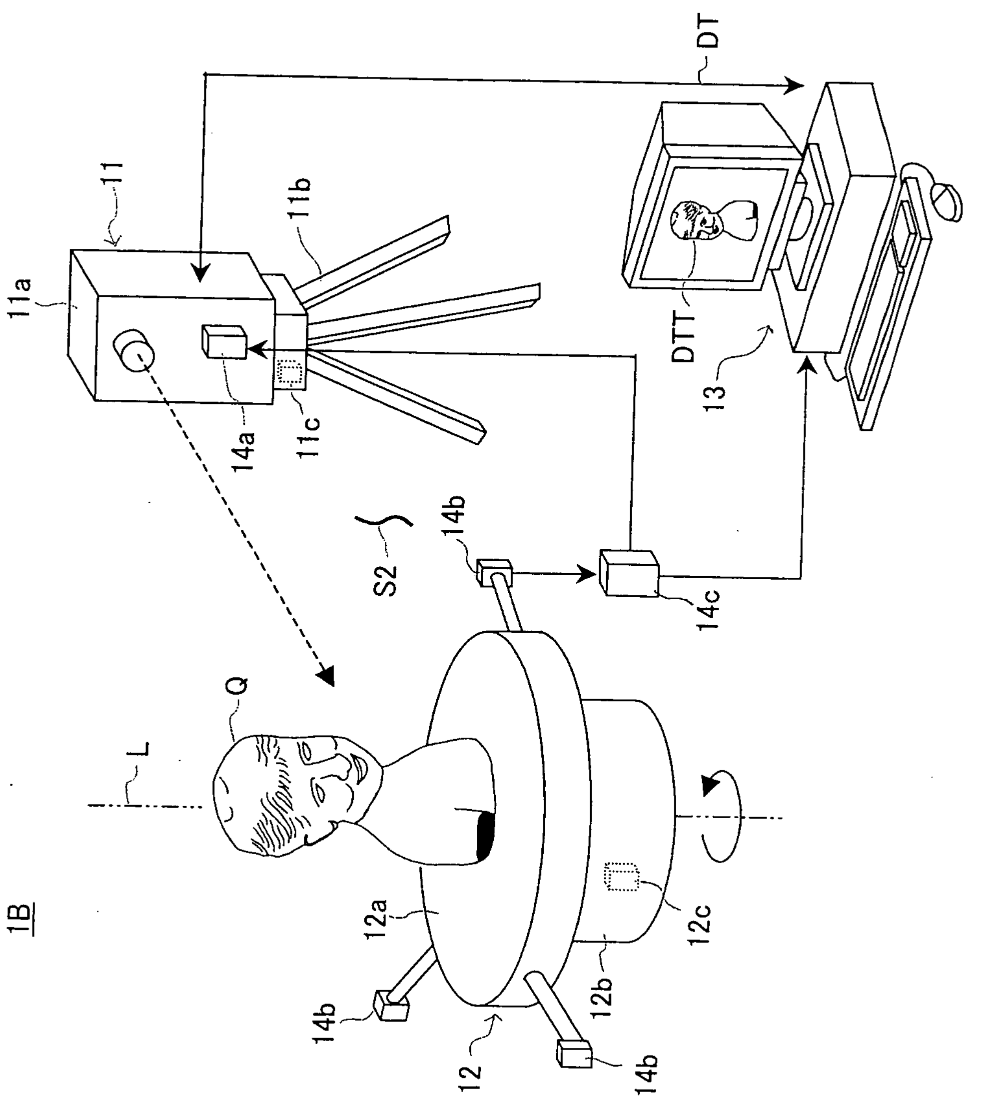

START
#11
ROTATIONAL ANGLE
θ = 0
#12
ADJUST POSITION AND
POSTURE OF
3-D CAMERA
#13
ADJUST TURN TABLE
#14
COMMAND FOR
PHOTOGRAPHING
#15
MEMORIZE VALUE
OF θ
#16
DETECT 3-D COORDINATE
OF RECEIVER
#17
GENERATE AND
MEMORIZE 3-D DATA DT
#18
OBTAIN ALL OF NECESSARY
3-D DATA DT?
NO
YES
#19
INTEGRATING
PROCESSING
END

【FIG. 7】



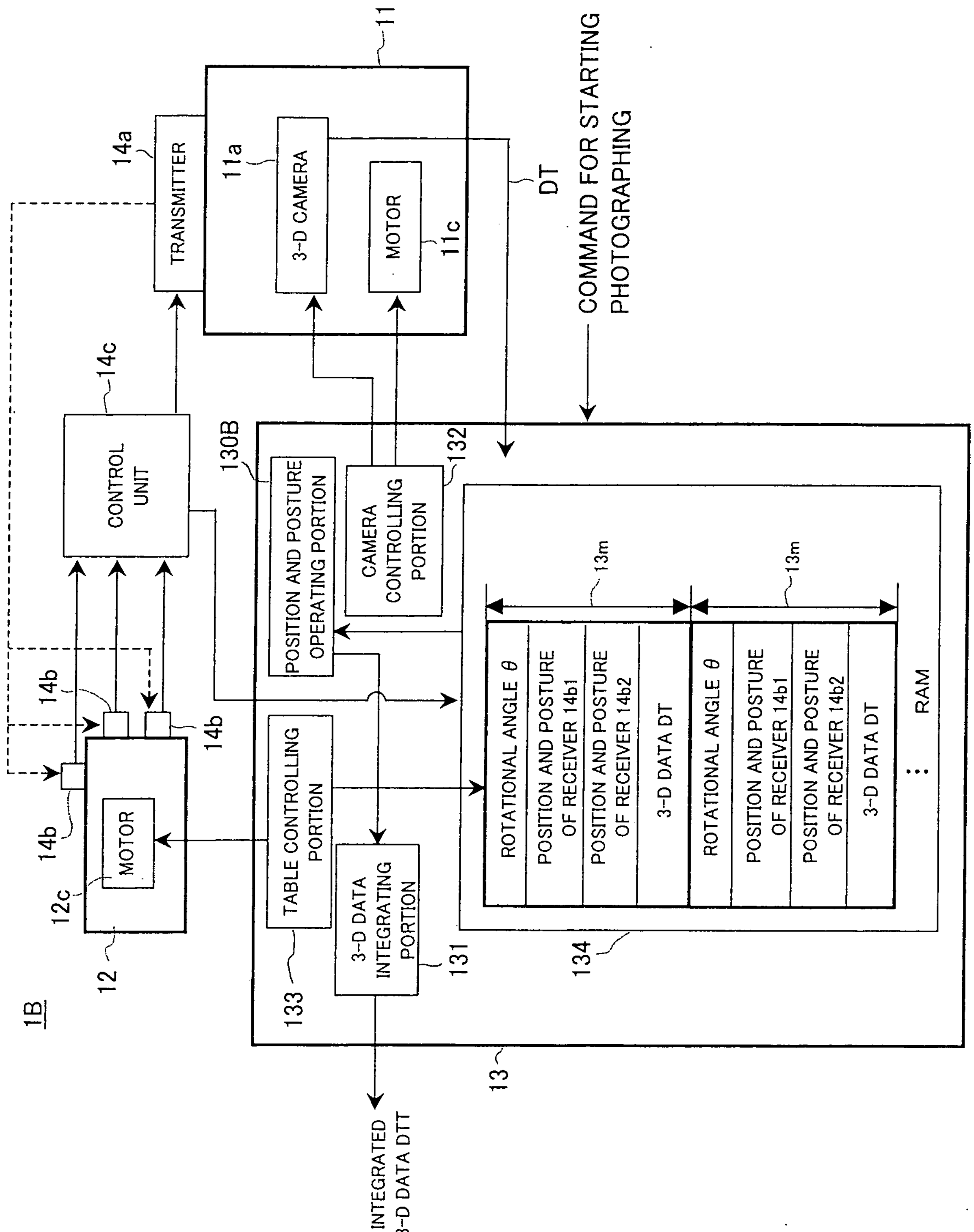
INTEGRATING PROCESSING
#21
READ OUT FRAME 13m
#22
JUDGE WHICH ONE OF RECEIVERS IS CLOSEST TO TRANSMITTER
#23
CALCULATE CONVERSION MATRIX M
#24
CONVERT 3-D COORDINATE OF 3-D DATA
#25
CONVERSION OF ALL COORDINATES OF 3-D DATA IS FINISHED?
NO
YES
#26
INTEGRATION OF 3-D DATA
END

【FIG. 8】

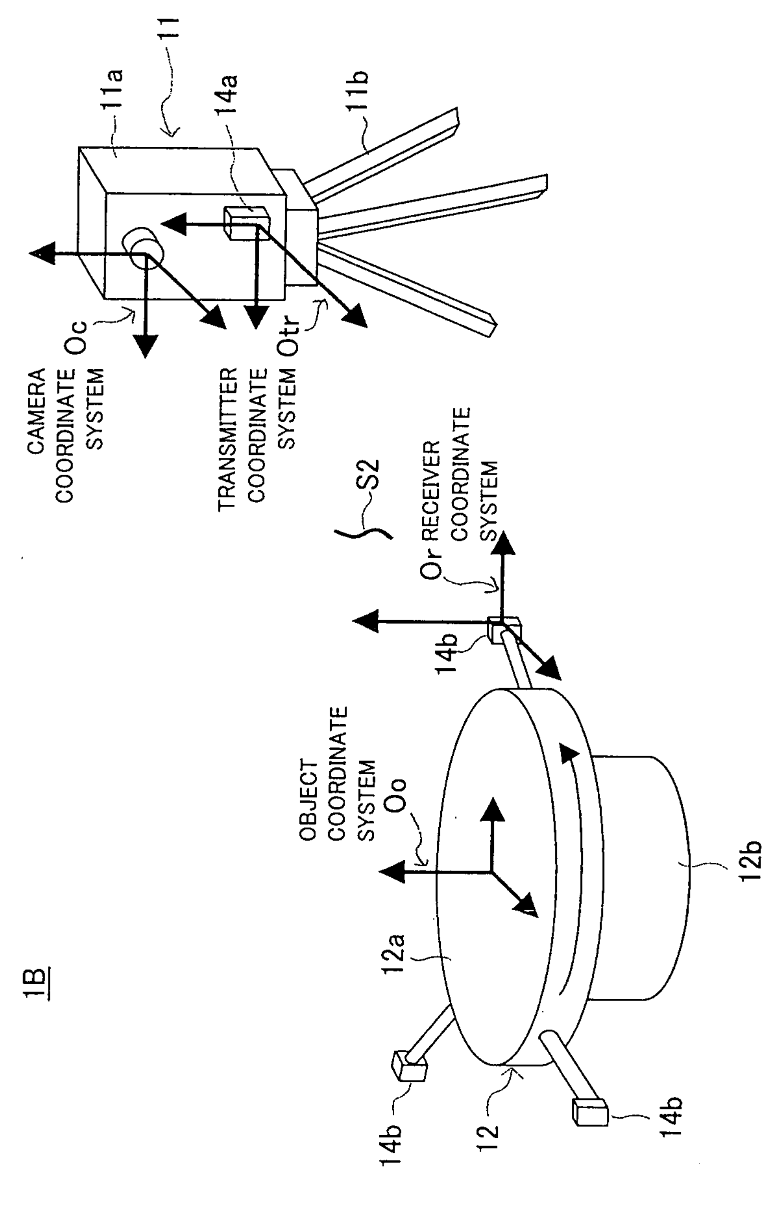


1B
L
Q
11a
11
11b
14a
11c
S2
14b
14c
DT
DTT
13
12a
12b
12c
12
14b
14b

【FIG. 9】

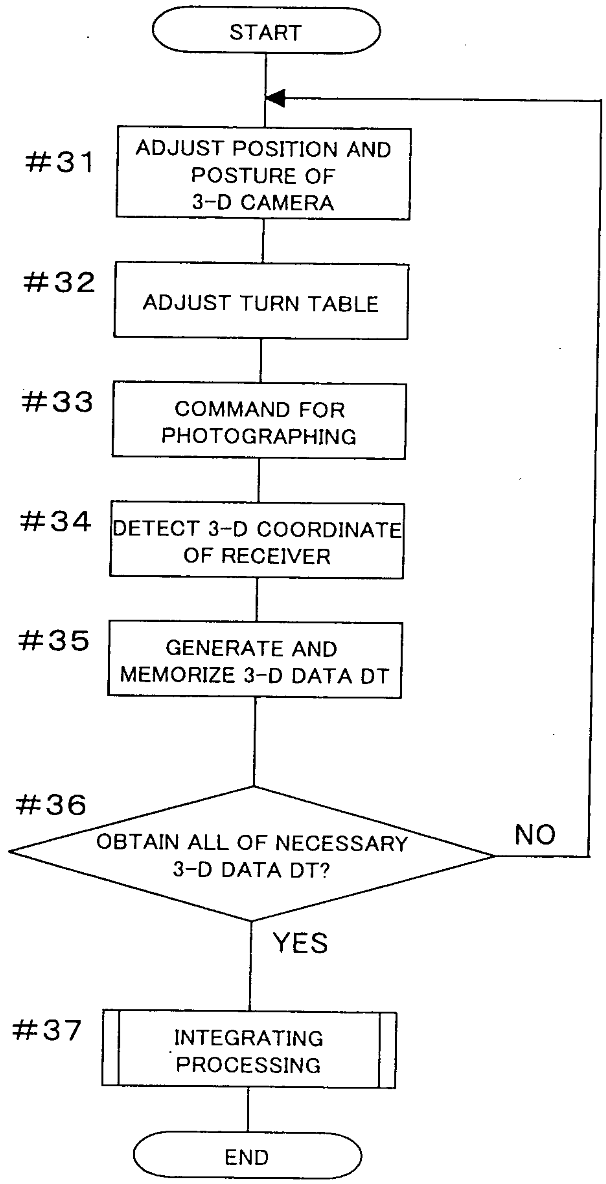

1B
12
12c
MOTOR
14b
14b
14b
CONTROL UNIT
14c
TRANSMITTER
14a
3-D CAMERA
11a
MOTOR
11c
11
DT
COMMAND FOR STARTING PHOTOGRAPHING
130B
POSITION AND POSTURE OPERATING PORTION
CAMERA CONTROLLING PORTION
132
TABLE CONTROLLING PORTION
133
3-D DATA INTEGRATING PORTION
131
13m
13m
ROTATIONAL ANGLE θ
POSITION AND POSTURE OF RECEIVER 14b1
POSITION AND POSTURE OF RECEIVER 14b2
3-D DATA DT
ROTATIONAL ANGLE θ
POSITION AND POSTURE OF RECEIVER 14b1
POSITION AND POSTURE OF RECEIVER 14b2
3-D DATA DT
RAM
134
13
INTEGRATED 3-D DATA DTT

【FIG. 10】

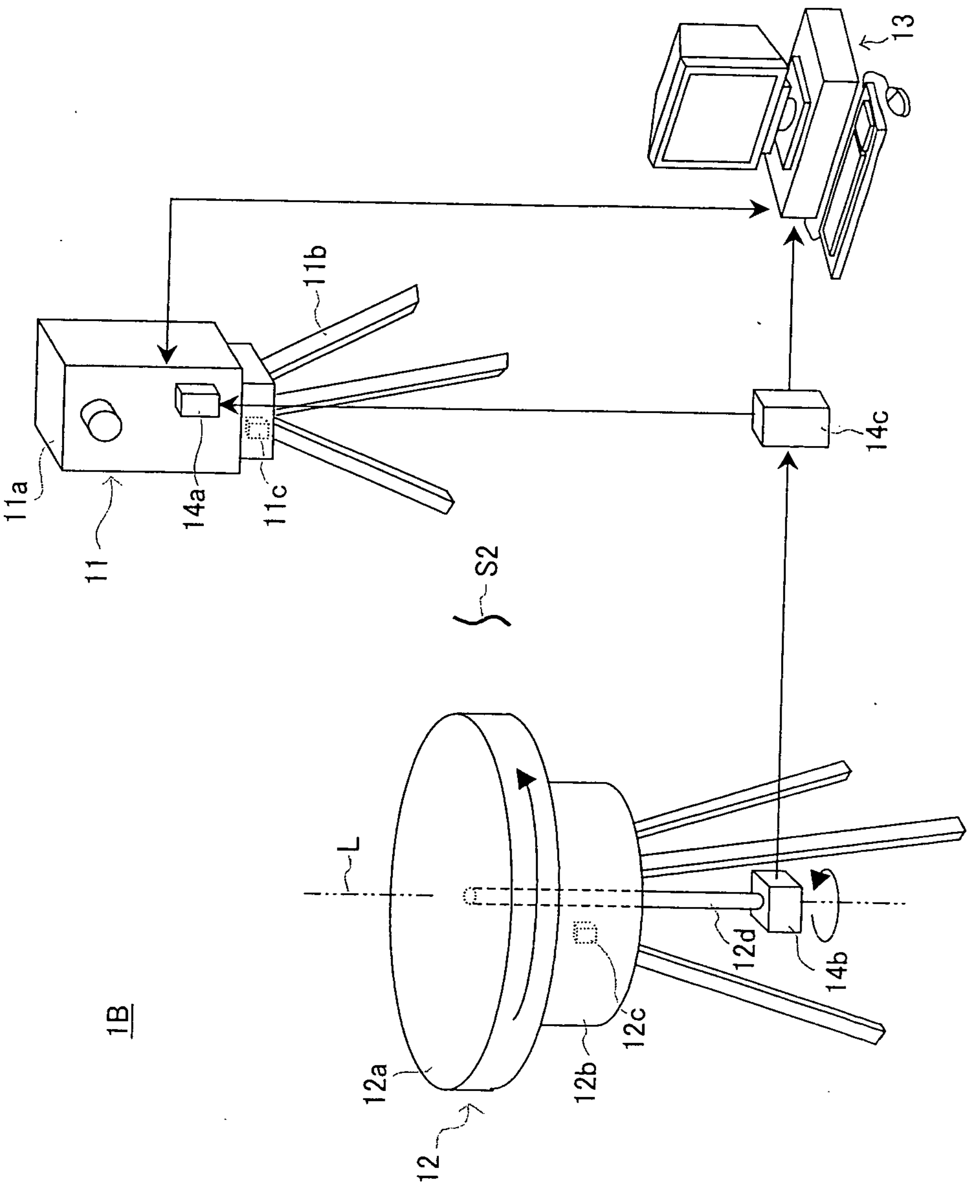


1B
11
11a
14a
11b
CAMERA COORDINATE SYSTEM
Oc
TRANSMITTER COORDINATE SYSTEM
Otr
S2
Or
RECEIVER COORDINATE SYSTEM
14b
OBJECT COORDINATE SYSTEM
Oo
12a
12b
12
14b
14b

【FIG. 11】


START
#31
ADJUST POSITION AND POSTURE OF 3-D CAMERA
#32
ADJUST TURN TABLE
#33
COMMAND FOR PHOTOGRAPHING
#34
DETECT 3-D COORDINATE OF RECEIVER
#35
GENERATE AND MEMORIZE 3-D DATA DT
#36
OBTAIN ALL OF NECESSARY 3-D DATA DT?
NO
YES
#37
INTEGRATING PROCESSING
END

【FIG. 12】



【FIG. 13】